

this it cannot be concluded that in no form does the split develop directly from the early reticulate structures, or that the telophasic alveolization, although irregular, may not later become so equalized as to constitute the first stages of the split; but it does follow that it is quite unsafe to use the principle of telophasic splitting as a premise from which to draw the conclusion that the approximation of thin threads in the early heterotypic prophase represents the reassociation of the halves of a single split chromosome. Although it is well to emphasize the importance of the premeiotic telophase, the ultimate solution of this perplexing problem must be reached mainly through a more refined analysis of those prophasic changes which have led a long list of investigators to the conclusion that the early heterotypic association of threads represents a conjugation of entire chromosomes which separate at the heterotypic division. To the reviewer the figures so far given by the English cytologists do not prove the theory they advocate.—L. W. SHARP.

**Carbohydrate economy of cacti.**—A distinct contribution to our knowledge of the carbohydrates in plants in general, and in the succulents in particular, is the report of SPOEHR'S investigations at the Desert Laboratory.<sup>8</sup> The methods employed give us what is probably the most complete analysis of the carbohydrates of a single plant tissue that we have, values for no less than 11 different groups of carbohydrates being ascertained, partly by direct determinations and partly by calculation.

The monograph is prefaced by a rather thorough discussion of carbohydrate metabolism in plants, and of the transformations of the carbohydrates under the influence of acid, alkali, oxidation, and enzymes; and of the energy relations of the products of these transformations. Then follows a description of the methods employed. *Opuntia phaeacantha* and *O. versicolor* furnished material for the studies. In preparing the tissues for carbohydrate analysis they were ground in a meat chopper and placed in an oven at 98° C. The precaution of DAVIS and DAISH of plunging the tissue into boiling alcohol was not deemed necessary. The disaccharides and polysaccharides were hydrolyzed by boiling with 1 per cent hydrochloric acid for 3 hours. All sugar determinations were made volumetrically with Fehling's solution. The pentoses were determined after fermenting away the hexoses with bakers' yeast.

The polysaccharides of the cactus are starch and xylan. The mucilage of *Opuntia* consists of 34.1 per cent d-glucose and 65.9 per cent l-xylose. Associated with it there is probably an acid. Glucuronic acid was found as a constituent of the sap. The formation of mucilage in special large cells could be watched under the microscope under certain conditions.

The relative abundance of the different groups of carbohydrates and also of water is profoundly affected by the seasonal variations of the external

<sup>8</sup> SPOEHR, H. A., The carbohydrate economy of the cacti. Carnegie Institution of Washington. Publ. 287. pp. 79. 1919.



conditions. From the cool and humid winter to the hot and dry fore-summer the water content of normal species of *Opuntia* may change from about 80 to 65 per cent, and then rise again to 83 per cent during the humid but hot mid-summer. "Low water-content and high temperatures are associated with: (1) increase of polysaccharides; (2) decrease of monosaccharides; (3) increase of pentosans. High water-content and lower temperatures are associated with: (1) decrease of polysaccharides; (2) increase of monosaccharides; (3) decrease of pentosans." The author points out the significant fact that "the greatest activity of the plant comes at a time when the content of monosaccharides and disaccharides is highest," in March and April, although he is careful to state that a relatively large supply of simple sugars is not the only prerequisite for growth, but is only one of many factors.

In an arid atmosphere the cut joints undergo considerable decrease in water content, while still remaining normal in appearance and activity. The loss of water by transpiration and evaporation is partly compensated for by the water formed in the combustion of sugars, and partly by the condensation of the simple sugars into polysaccharides. Under drought the former decrease, while the latter and the pentosans increase, in total amount. The author suggests that the great imbibitional force of the pentosans may prevent the use of water for hydrolytic processes, when water becomes scarce in the tissue. These phenomena are closely correlated with temperature effects, when the latter are studied independently of varying moisture supply. Enzyme equilibria are discussed in connection with these two factors.

During the night the succulents respire sugar to acids, principally malic. This is not accompanied by an accumulation of alcohol. In an oxygen-free atmosphere, however, there is much less acid formed, and a very considerable amount of alcohol produced. One molecule of malic acid furnishes two of carbon dioxide and one of ethyl alcohol. Under these anaerobic conditions more sugar is consumed per unit of energy than under aerobic conditions. This is accompanied by an increase in the water content of the tissue.

During starvation the joints of *Opuntia* maintain the same relative proportions of the various carbohydrates. This disproves the theory that the pentoses are waste products of metabolism, since then they would show an increase. The water relations of the tissue during starvation and during periods of feeding on sugar solutions are discussed at some length.

SPOEHR advances the theory that the pentoses may be formed from glucuronic acid by the loss of a molecule of carbon dioxide, and discusses the isomerism relations between the hexoses and the corresponding pentoses that would be formed through the intermediary of glucuronic acid.—J. J. WILLAMAN.

**Transpiration in tropical rain forests.**—The lack of experimental data as to the conditions of plant growth and activity in tropical rain forests is apparently leading to some desirable investigation. A notable contribution in this